LOCALIZATION OF PLASTIC STRAIN IN ALLOY 718 USING DIGITAL IMAGE CORRELATION

Malo Jullien, Damien Texier, Ali Rouwane, Jean-Charles Passieux, Institut Clement Ader (ICA) - UMR CNRS 5312, Toulouse, France
malo.jullien@mines-albi.fr
Marc Legros, CEMES-UPR CNRS 8011, Toulouse, France

Keywords: High resolution-digital image correlation (HR-DIC), Superalloys, Slip activity, Laser Scanning Confocal Microscopy (LSCM)

High Resolution-Digital Image Correlation (HR-DIC) is a powerful tool to assess quantitative kinematic fields across length scales. Recently, HR-DIC was used to identify slip activity at the microstructure scale in different single- or poly-crystalline materials under tensile loading [1-4]. Identification of slip systems was possible using micrographs from either scanning electron microscopes (SEM) or laser scanning confocal microscopes (LSCM). SEM micrographs provide a high spatial resolution and scanning repeatability while LSCM micrographs provide out-of-plane measurements. Both imaging techniques are therefore complementary to identify crystallographic slip activity at the sub-grain scale.

In the present work, HR-DIC paired with *ex-situ* LSCM observations was used in order to identify strain localization and subsequently slip activity in the Alloy 718 under tensile loading at room temperature. Tensile specimens were subjected to a two-step tensile test, interrupted at 0.1% and 0.4% plastic strain. Full field in-plane kinematics fields and height measurements were assessed using the DisOpticalFlow OpenCV library [5].

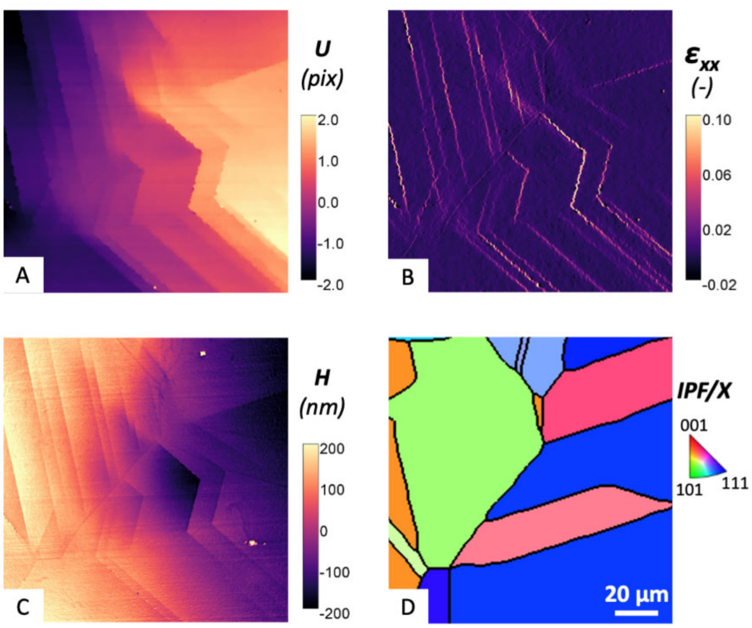

Figure: HR-DIC maps of a strained specimen; A) displacement field, B) ε_{xx} strain, C) height map and D) EBSD map of the area.

Transgranular strain localization was depicted in a small region of interest and evidenced both in-plane and out-of-plane displacement discontinuities at the sub-grain level (Figure). The emergence of dislocations along {111} slip planes at the sample surface results in the development of roughness that increases with plastic deformation. After 0.4% plastic deformation, the tensile specimen was polished to remove surface roughness and to identify dislocation landscape in a sub-surface plane using electron backscattered diffraction (EBSD) and high resolution nanoindentation maps. The results from both these techniques were compared with projection of slip bands identified using HR-DIC techniques.

References:
[1] Chen, Z., & Daly, S. H. (2017). Active slip system identification in polycrystalline metals by digital image correlation (DIC). Experimental Mechanics, 57(1), 115-127.
[2] Bourdin, F., et al. (2018). Measurements of plastic localization by heaviside-digital image correlation. Acta Materialia, 157, 307-325.
[3] Liu, J. H., et al (2019). In-plane and out-of-plane deformation at the sub-grain scale in polycrystalline materials assessed by confocal microscopy. Acta Materialia, 169, 260-274.
[4] Lunt, D., et al (2020). Comparison of sub-grain scale digital image correlation calculated using commercial and open-source software packages. Materials Characterization, 163, 110271.
[5] Kroeger, T et al (2016). Fast Optical Flowusing Dense. European Conference on Computer Vision. 471-488.